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Gray Davis
Governor

December 20, 2002

Brian Alcorn
Energy Efficiency and Demand
Analysis Division, MS 28
California Energy Commission
1516 9th Street
Sacramento, California 95814

Dear Mr. Alcorn:

Thank you for the information presented at the Cal-OSHA Indoor Air Quality Advisory Committee meeting regarding the November 18, 2002 Draft Building Energy Efficiency Standards, Title 24, Operation and Control Requirements for Minimum Quantities of Outdoor Air, Demand Ventilation Controls. The Title 24 design standards, and their reflection in Cal-OSHA's Title 8 operation and maintenance standards for workplaces, have been essential for the protection of public and worker health in schools, offices, and other nonresidential buildings. Our comments are listed below.

Our major concern is that the installation, operation, and maintenance problems expected for demand control ventilation (DCV) systems with carbon dioxide (CO₂) sensors are likely to produce harmful indoor air quality, health, and productivity impacts. DCV systems have the potential to improve building performance in the future, but they require careful evaluation and further improvement to assure that they will actually achieve those performance goals and avoid adverse impacts. Before considering a draft standard, we recommend that additional work be done on DCV systems to test and improve their long-term reliability, develop more specific control requirements (especially for operation and maintenance), and demonstrate their performance.

We also have comments on the existing requirements for vented combustion appliances and exhaust ventilation in new residences. Combustion pollutants and moisture from cooking appliances, bathrooms, and utility rooms are often major indoor air quality problems in homes, and existing approaches should be used to reduce the risks from such pollutant exposures.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Website: <http://www.arb.ca.gov>.

California Environmental Protection Agency

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Our specific comments regarding DCV are the following:

1. Low Reliability of DCV Systems. DCV systems for economizers have not yet proved to be reliable over the long term. System commissioning and ongoing maintenance needs to be assured, such as through maintenance contracts and lease provisions. California and North America have little experience with such DCV systems – they have been an option in the Title 24 standards, but very few buildings have used them so far.¹ Although modeling studies indicate that the energy and indoor air quality benefits of DCV with CO₂ sensors are potentially substantial, field studies² and HVAC professional experience³ indicate that such DCV systems require a significant additional effort for proper installation and maintenance in order to achieve those benefits. The Los Angeles Unified School District recently removed DCV systems from several new classrooms after encountering operation and maintenance (O&M) problems with the systems.⁴

O&M problems with HVAC systems in nonresidential buildings in California are already far too common. Preliminary findings from a recent CEC Public Interest Energy Research (PIER) program study of 140 commercial building HVAC systems indicate that 70% of the systems had economizers with serious problems, 32% had fan cycling problems, and 7% had no outdoor air.⁵ Package HVAC systems, which are commonly used in school buildings, are more likely to have problems than are built-up systems.⁶ Clearly, adding a complex function to HVAC systems that are already poorly maintained will not help save energy or improve indoor air quality, and it may discredit or hamper any future efforts in this area.

¹ Jon Leber, California Energy Commission. Presentation on proposed Section 121 revisions, Cal OSHA IAQ Advisory Committee, Oakland, California, November 20, 2002.

² Emmerich, SJ, and Persily, AK, 1997. Literature review of CO₂-based Demand-Controlled Ventilation. <http://www.fire.nist.gov/bfrlpubs/build97/art015.html>, ASHRAE Transactions 103(2).

³ David Bearg, AIRxpert Systems, Concord, MA. As quoted in Turpin, J., 2001. The dilemma over demand control ventilation. Engineered Systems, July 31, 2001.

http://www.esmagazine.com/es/cda/articleinformation/features/bnp_features_item/0,2503,60429,00.html

⁴ Jay C. Brakensiek, Office of Environmental Health and Safety Los Angeles Unified School District. "Strategies for Working in Urban School Districts - Case Study at Los Angeles Unified School District," Health and Environment Electronic Seminar, Association of State and Territorial Health Officers, December 5, 2002. <http://www.astho.org/pubs/DECEMBER2002-Brakensiek.ppt>

⁵ Jacobs, P, 2002. "Packaged HVAC Problems." Architectural Energy Corporation. Energy Efficient and Affordable Small Commercial and Residential Buildings Research Program, PIER Diagnostics Meeting, Oakland, CA, April 16-17, 2002. <http://aes1.archenergy.com/cec-eeb/docs/DiagnosticsMtg/JacobsPierDiagnosticsmeeting/index.htm>, slide 13 of 22.

⁶ Braun, J, and Li, H, 2002. Fault Diagnostics and Detection (FDD) for Rooftop Air Conditioning. Purdue University. Energy Efficient and Affordable Small Commercial and Residential Buildings Research Program, PIER Diagnostics Meeting, Oakland, CA, April 16-17, 2002, PIER presentation. <http://aes1.archenergy.com/cec-eeb/docs/DiagnosticsMtg/Braun-RooftopAC-Diagnostics/index.htm>, slides 3 and 21.

2. Incomplete Assessment of DCV Systems. The assessment of DCV systems currently in progress under the CEC's PIER program⁷ should be completed prior to proposing DCV requirements. The contractor's recommendations from the assessment are due to be delivered to the CEC in the first quarter of 2003. Additionally, demonstration programs of DCV systems are needed before widespread application is required in California.
3. Incomplete Basis of CO₂ Limits. The proposed 1100 ppm CO₂ limit for the DCV sensors has not been sufficiently evaluated. The current Title 24 limit of 800 ppm CO₂ was adopted in 1991. It was consistent with recommendations from a study of worker's environmental complaints in office buildings⁸ and with California Department of Health Services recommendations for office building investigations.⁹

The supporting document for the proposed standard cites two published literature reviews of health symptoms and other responses in office building workers that suggest 1000-1200 ppm CO₂ as acceptable levels for indoor environments.¹⁰ However, findings from a recent epidemiological study of workers in 100 U.S. office buildings indicate that increases in sick building syndrome symptoms correlate significantly with indoor CO₂ levels down to outdoor levels.¹¹ Additionally, it is not clear what levels of CO₂ would be adequate for K-12 school buildings, where indoor pollutant sources may differ substantially from those in office buildings, and where many building occupants are sensitive (e.g., children, pregnant women, asthmatics).

Finally, CO₂ is only a sufficient indicator for human bioeffluents, i.e. exhaled breath. It does not account for other pollutant emissions from materials and product sources that may exist in the indoor spaces.¹² Thus, basing ventilation on CO₂ alone does not offer adequate protection of building occupants. Based on current indoor air quality research and the limitation of CO₂ as a protective indicator for children, the 800 ppm limit remains a more appropriate limit if DCV were to be used.

⁷ Energy Efficient and Affordable Small Commercial and Residential Buildings Research Program, PIER Program, Technical Briefing Power Point Presentation, June 4, 2002 <http://aes1.archenergy.com/cec-eeb/>, Advanced Load Control, Demand-Controlled Ventilation Assessment, Task List.

⁸ Rajhans, G, 1983. Indoor air quality and CO₂ levels. Occupational Health in Ontario, Canada 4:160-167. Cited in 1985 CEC Nonresidential Buildings Energy Conservation Manual, Appendix D.

⁹ California Department of Health Services, _____. A "Do-it-yourself" Inspection of a Ventilation System. DHS, Air and Industrial Hygiene Laboratory, Berkeley CA. <http://www.cal-iaq.org/>

¹⁰ Mendel, MM, 1993, Indoor Air, pp. 227-236. OA Seppanen, OA, et al., 1999, Indoor Air, pp. 226-252.

¹¹ Apte, MG, and Erdmann, CA, October 16, 2002. Associations of Indoor Carbon Dioxide Concentrations, VOCs, and Environmental Susceptibilities with Mucous Membrane and Lower Respiratory Sick Building Syndrome Symptoms in the BASE Study: Analyses of the 100 Building Dataset. LBNL-51570. Indoor Environment Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, CA.

¹² Persily, AK, 2000. The relationship between indoor air quality and carbon dioxide. Indoor Air '96, the 7th International Conference on Indoor Air Quality and Climate, July 21-26, 1996, Nagoya, Japan, Vol. 2, pp. 961-966. <http://www.fire.nist.gov/bfrlpubs/build96/art103.html>. See also Footnote 13.

4. Ambiguous DCV Size Limitation. When proposed in the future, draft DCV requirements should clarify what, if any, is the minimum HVAC unit rating and room size where an economizer is required. Section 121(c)3, Part B indicates the minimum design occupant density, but not the actual floor area, space volume, number of occupants, or unit rating. A presentation by CEC staff in Oakland on November 20, 2002 at the Cal OSHA IAQ Advisory Committee meeting indicated that the minimum unit rating would be 5 tons and the minimum room size for economizers would be 2500 square feet, but this is not clear in the proposed revisions.
5. Incomplete DCV Control Specifications. Any proposed standards should include minimum and recommended performance specifications for sensor response time, pre-occupancy flushing programs, defaults in failure modes, calibration reminders, out of range indicators, and sensor location. These specifications are necessary to ensure that the ventilation standards are actually met during all conditions, especially when rooms are repeatedly emptied and filled during the day, for example, classrooms with numerous breaks and recess periods. For poorly mixed rooms such as those with only one supply register, it would be necessary to locate sensors in the middle of the room, rather than at the return air inlet. It is also advisable to measure CO₂ in the room when installing and calibrating the sensors.¹³ An evaluation program would be needed to follow up on any DCV standards to review actual O&M practices and to refine the implementation of the standards.
6. Implementation of Pre-Occupancy Ventilation Requirements. Section 121(c) requires building ventilation systems to flush the building volume before daily occupancy. This existing regulation has been shown to be effective in reducing the exposure to pollutants emitted from building materials and HVAC systems. It would need to be incorporated into any DCV requirements, perhaps through a timer control requirement.

In addition, the implementation of this and the other ventilation regulations in operating buildings has been limited. In order to facilitate compliance, we recommend clarifying how this pre-occupancy will be verified by building inspectors, and by building managers and Cal-OSHA inspectors for occupied buildings. Presumably, inspectors would at least need specific calculations, control system settings, and outdoor airflow rates to show that the building is being flushed as required.

Our specific concerns regarding the draft standards for residential buildings are as follows:

1. Inadequate Residential Combustion Appliance Safety. We recommend that the CEC require combustion appliance safety testing in new homes and additions involving major HVAC modifications. This testing involves measuring the carbon monoxide levels in the exhaust of all gas appliances, the gas pressure to those appliances, the draft in the exhaust flues, and the potential for backdrafting. These measures are

¹³ Turpin, J., 2001. The dilemma over demand control ventilation. Engineered Systems, July 31, 2001. http://www.esmagazine.com/es/cda/articleinformation/features/bnp_features_item/0,2503,60429,00.html

currently considered best practice,¹⁴ and are used widely in energy efficient home programs and California's home weatherization programs.¹⁵ ARB recommended this practice in its Indoor Air Quality Guideline, Combustion Pollutants in Your Home, published in 1994.¹⁶ This test will assure the construction quality, energy efficiency, and indoor air quality of homes, and also reduce the liability of builders and installers.

2. Inadequate Control of Residential Emissions and Moisture. We recommend that the CEC clarify and revise the building standards to require outdoor exhaust ventilation for cooking appliances, bathrooms, and utility rooms. This approach is currently required in some other states,^{17,18} e.g., low-noise exhaust fans, humidistat controls, and duct layout specifications. Energy efficient builders consider this approach as best practice.¹⁹ In addition, the CEC recommends this approach for "quality construction."²⁰

Thank you for your consideration of our comments. We look forward to working with you to assure good indoor air quality in California's buildings, while achieving improved energy efficiency. If you have any questions or need further information, please contact me at (916) 323-1504, or mjenkins@arb.ca.gov. You may also contact Tom Phillips of my staff at (916) 322-7145, or tphillip@arb.ca.gov.

Sincerely,

Peggy Jenkins, Manager
Indoor Exposure Assessment Section

cc: Tom Phillips
Air Pollution Specialist

¹⁴ deKiefer, R, May/June 1985. Combustion Safety Checks: How Not to Kill Your Clients. Home Energy Magazine. <http://www.proctoreng.com/articles/rob.html>.

¹⁵ Richard Heath and Associates, July 1999. Conventional Home Weatherization Installation Standards. Prepared for California Department of Community Services and Development, Sacramento, CA.

¹⁶ <http://www.arb.ca.gov/research/indoor/combustf.htm>.

¹⁷ Washington State Building Code Council, 2000. Washington State Ventilation and Indoor Air Quality Code (2000 edition). Chapter 3, Ventilation Systems. Guidance.

<http://www.energy.wsu.edu/buildings/2001documents/2000VIAQ.pdf>,

http://www.energy.wsu.edu/buildings/files/IAQ/02_023_Vent_fct_9_19.pdf. Washington State University, Energy Program, Building Standards and Science, Olympia, WA.

¹⁸ Minnesota Department of Commerce, 2002. Energy Code Main Reference Page.

<http://www.commerce.state.mn.us/pages/Energy/Builders/ECODEMain.htm>, Comparison Chart, Ch. 12, Residential Ventilation.

¹⁹ EEBA, 2002. Criteria for Energy and Resource Efficient Building. Energy Efficient Builders Association. <http://www.eeba.org/technology/criteria.htm>, Indoor Environment Criteria.

Otto, D, November 14, 2002. It's Not About the Efficiency Energy. Energy Efficient Builders Association. <http://www.eeba.org/technology/articles/otto-021114.htm>.

²⁰ http://www.energy.ca.gov/efficiency/qualityhomes/mechanical_ventilation.html